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USING ABSORBABLE MAGNESIUM RINGS

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# A PRACTICAL MECHANICAL METHOD OF END-TO-END ANASTOMOSIS OF BLOOD-VESSELS

USING ABSORBABLE MAGNESIUM RINGS

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This work was done in the laboratory of the department of Experimental Surgery of Northwestern University Medical School, with the cooperation and assistance of Prof. Robert Zeit and Drs. Wolfer, Violet Deason and Solmon. It is accomplished by the use of rings of metallic magnesium.

## PHYSICAL PROPERTIES AND METALLURGY OF MAGNESIUM

Magnesium is a hard, silver-white metal, having a specific gravity of 1.75 and possessing a melting point of 800 degrees. As it tarnishes in the air the bright luster is soon lost, but the change is unimportant at the ordinary temperature. At a high temperature combustion follows, with production of the well-known brilliant white light. At ordinary room temperature the action increases and hydrogen gas is slowly liberated, the hydroxid of magnesium being formed at the same time.

The action of water on magnesium is hastened by the presence of salts, such as sodium chlorid, from which it follows that in the juices of the body the solution or disappearance of the metal would be more rapid than in water alone. However, even with salts present, the action is relatively slow and the hydrogen set free is scarcely appreciable. Under proper conditions 24 milligrams of magnesium will liberate 2 milligrams of hydrogen, or 22.4 c.c. at the normal temperature of zero centigrade. This volume would be somewhat greater at body temperature; approximately, 1 mg. of the metal will liberate 1 cubic centimeter of the gas.

A 3.5 mm. ring, such as would be used on a dog's carotid, produces about 60 c.c. of gas. A 9 mm. ring, such as would be used on a human femoral, produces about 240 c.c. of gas. This gas is produced slowly and is absorbed almost as fast as produced; hence it does no harm.

Several different explanations of the action of magnesium with salt solution have been given but for all practical purposes the formation of magnesium hydroxid and hydrogen may be considered as covering the main features of the changes. The products formed are non-toxic and non-irritant.

The metal is very brittle and breaks suddenly when it is bent at a right angle, but it is quite resistant to a pull or crush.

#### STERILIZATION

The rings are boiled in water from Lake Michigan, which does not contain much salt. Where the water contains any considerable amount of salts, one should use distilled water.

#### METHODS

Many methods of blood-vessel anastomosis have been advanced but they are all lacking in some way. The only methods at all practicable at the present time are first, the Payr method, second, the suture method.

The Payr method constricts the lumen of the vessel and is very liable to secondary thrombosis, while the technic of the suture method is very difficult. In the method here advanced these objections are overcome. There is no constriction, secondary thrombosis is impossible and the technic is simplicity itself. In a properly applied union there is not one drop of hemorrhage. One is master of the situation at all times, and does not have to try slight pressure, hot sponges, and other temporizing and uncertain methods, to stop the oozing of the blood after the clamps are removed. He knows that when the clamps are removed his junction will be perfect; if anything is wrong, it will be easily detected during the operation and can be remedied at once. While a suture may look ever so well, it may still bleed furiously when the clamps are removed, showing that the approximation is imperfect and the whole operation is destroyed beyond repair.

Secondary attempts at repair have in my experience been failures in every instance.

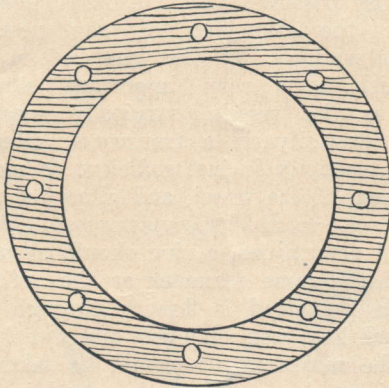


Fig. 1.—A ring, a flat piece of metallic magnesium, with edges rounded off and eight holes punched in it equidistant. These holes are counter sunk so that their edges will not cut the threads.

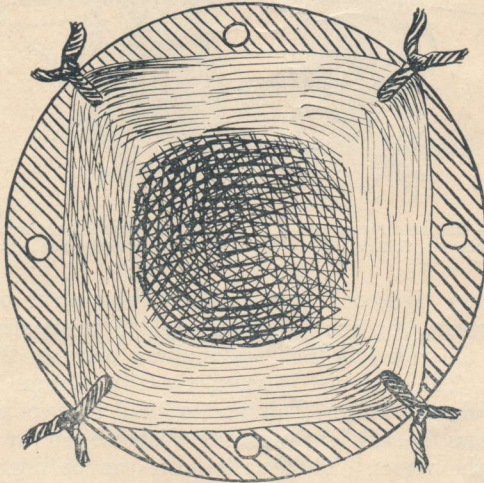


Fig. 2.—Vessel sewed into the ring, using every other hole; the sutures are triple O silk.

#### TECHNIC OF MAGNESIUM RING BLOOD-VESSEL ANASTOMOSIS

The first step in the operation is the dissection and exposure of the vessel. This must be done carefully,

and all collaterals must be clamped, cut and ligated. Then the loose sheath and adventitia is dissected off as completely as possible. As the blood flows through the vessel, the diameter of the vessel is accurately determined by the use of a millimeter gauge, which is a very important step in the operation, as the vessels, surgically speaking, have very little elasticity in a transverse direction; the fact is this elasticity is just sufficient to maintain the original lumen of the vessel, and allow for the everted portion necessary to make the anastomosis. The diameter of the vessel determined, a ring should be used having a lumen of the same diameter as that of the blood-vessel, while the blood is flowing through the vessel. If the vessel has been clamped and cut before it is measured the measurement should be taken proximal to the proximal clamp. Next the vessel is clamped in two places by means of the ordinary Crile clamp. These

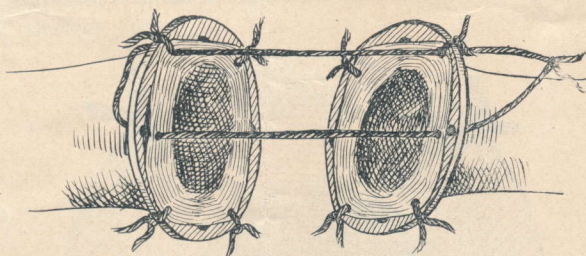


Fig. 3.—The two rings and one of the four approximating sutures of linen passed. Three others are passed in exactly the same way.

clamps are tightened just sufficiently to shut off the blood-stream, but not tightly enough to traumatize the intima; the vessel is then cut midway between the two clamps. The distance between the two clamps before cutting should be an inch and a half to two inches; this allows a sufficient working distance on each cut end of the vessel. The anastomosis can be done with much less space than this if necessary, but with a corresponding increase in the difficulties of the technic. After the vessel is cut the ends retract widely. The cut ends draw themselves down into and are covered over by a portion of the sheath and adventitia; grasp this connective tissue with tissue forceps; draw it up, and cut it off flush with the cut end of each vessel. The adventitia

then slips well back, and is entirely out of the way for the remainder of the operation. Each end of the blood-vessel is then washed out with a normal saline solution discharged from a large syringe. In the smaller vessels, it is best to grasp them just distal to the clamp with a Knapp trachoma roller, and thus the clotted blood is forced out of them. During this process of rolling, a stream of saline solution should be playing on the cut end of the vessel.

The vessel is now ready for the application of the rings. These rings may be used in the following ways: First, one ring and a lock-stitch; second, two rings which

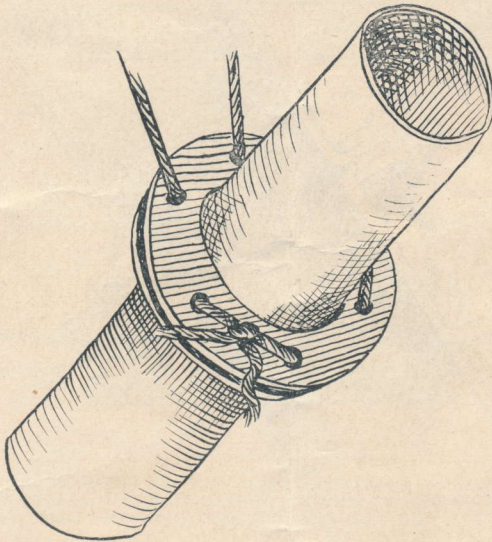


Fig. 4.—The two rings drawn together and three of the approximating sutures tied while the fourth one is drawn up ready to be tied.

are sewed into the respective ends of the vessel; third, two rings and four ligatures; fourth, two rings, one of which is threaded.

*First Method: One ring and lock stitch.*

An appropriate-sized ring is slipped over one end of the vessel; then four guy ligatures, equidistant, are passed through the ends of the vessel; next the lock stitch is passed, first through the vessel walls, and then through the rings. The loops of the stitch are cut, and the appropriate ends tied together. The lock stitch consists of eight needles; or if the

ring has more than eight holes, then have the same number of needles as there are holes in the ring. These needles are all threaded on a single thread, being spaced about eight inches apart. The two ends of the thread are passed through the same needle. In this method the ring acts only as a splint, to prevent constriction of the vessel, and every portion of the vessel wall is in the grasp of the suture; hence there is practically no hemorrhage.

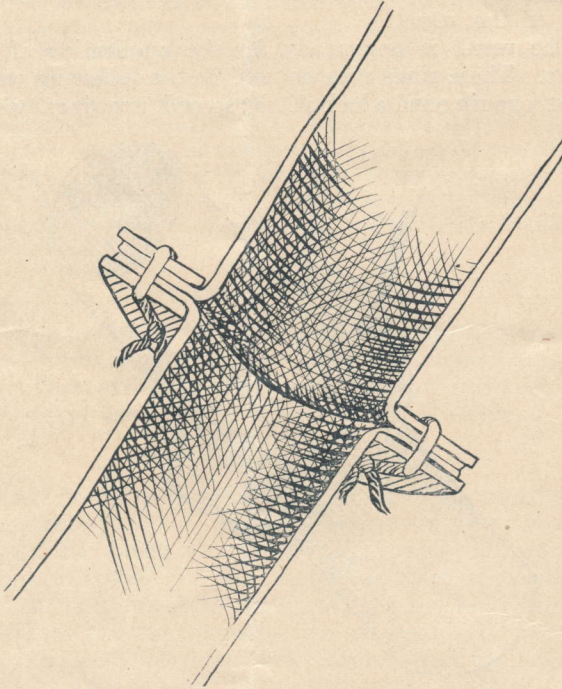


Fig. 5.—A longitudinal section of the vessel. It also shows that no foreign material of any kind comes in contact with the blood after the operation is completed.

*Second Method:* Two rings are used which are sewed into the respective ends of the vessel, by four sutures of triple-0 silk, using every other hole (Fig. 2).

In tying these sutures, care should be taken that the knot is on the outer edge of the ring, or on the opposite side of the ring from the intima of the vessel. After the rings have been sewed into the ends of both vessels, the two rings are united by four stitches passing first through one ring, then through the blood-vessel, then through the blood vessel on the opposite side, and finally through the opposite ring. These four sutures are then tied over the edge of the rings. This

method is a poor one, first, because there is a liability of the suture cutting through the metal of the ring; second, it only provides four points of pressure on the ring and hemorrhage is liable to occur; third, it gives a chance for spreading of the rings at their inner edge with exposure of the sutures and consequent thrombosis.

The sutures joining the rings together had better be placed as a mattress stitch, which is done in the following way (Fig. 3):

Four strands of fine silk or linen about eight inches long are selected and armed with a needle on each end. These sutures should be perfectly smooth and withstand at least an 8-lb. pull. One of the needles is passed through the same hole in the ring



Fig. 6.—A magnesium plate suitable for repair of a lateral slit in a vessel.

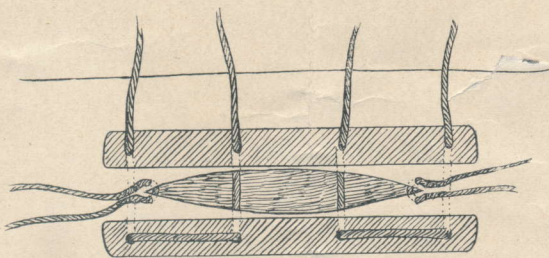


Fig. 7.—A lateral slit with a guy rope passed through each end of the slit and two mattress sutures passed through the two plates and the vessel wall ready to be drawn up and tied.

through which a fine silk suture has been passed; the other end of the suture is passed through an adjoining hole in the ring, and then through the blood-vessel wall. On the other ring the sutures are passed through the same relative holes. Four of these mattress sutures are passed. After the sutures are all in place, they are pulled together and approximate the rings accurately, with no tendency for the rings to spread, and there is no liability of the sutures cutting through the large amount of metal in their grasp (Fig. 4).

#### *Third Method: Two rings and four guy ligatures.*

An appropriate-sized ring is slipped over each end of the vessel. Two ends of the vessel are then united together by four guy ligatures placed equidistant from each other. A suture is then passed through the ring, through the two ends of the

vessel, immediately beneath the guy ligatures; then through a hole in the opposite ring. The suture is passed back through an adjoining hole in the second ring, through the two ends of the blood-vessel, midway between the guy ligatures and finally through the adjoining hole of the first ring. Three other sutures are passed and then the four sutures are drawn up and tied. The guy ligatures are cut and the operation is completed.

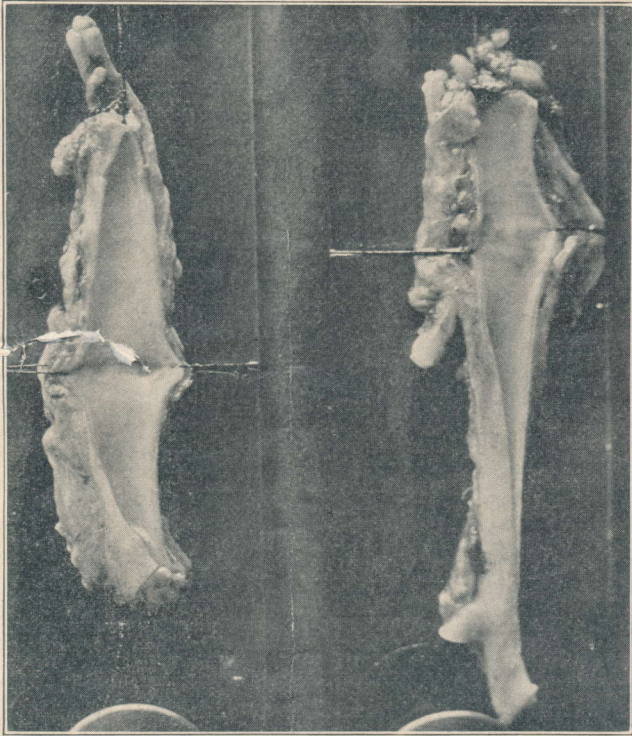


Fig. 8.—Result of anastomosis of common carotids after 100 days. No clots, no thrombosis, no constriction; arteries were pulsating and spurted when cut; magnesium rings absorbed.

*Fourth Method:* Two rings, one of which is threaded.

Four strands of fine linen are armed on each end with a needle. These strands are threaded through an appropriate-sized ring in such a manner as to make four mattress stitches, having all the loops on the same side of the ring; this ring is then slipped over the cut end of the vessel; the vessel is grasped at points exactly opposite, by two very fine tenaculums; the needle directly opposite the first needle inserted

is now passed through the blood-vessel, exactly between the tenaculums but on the opposite side; the remaining needles

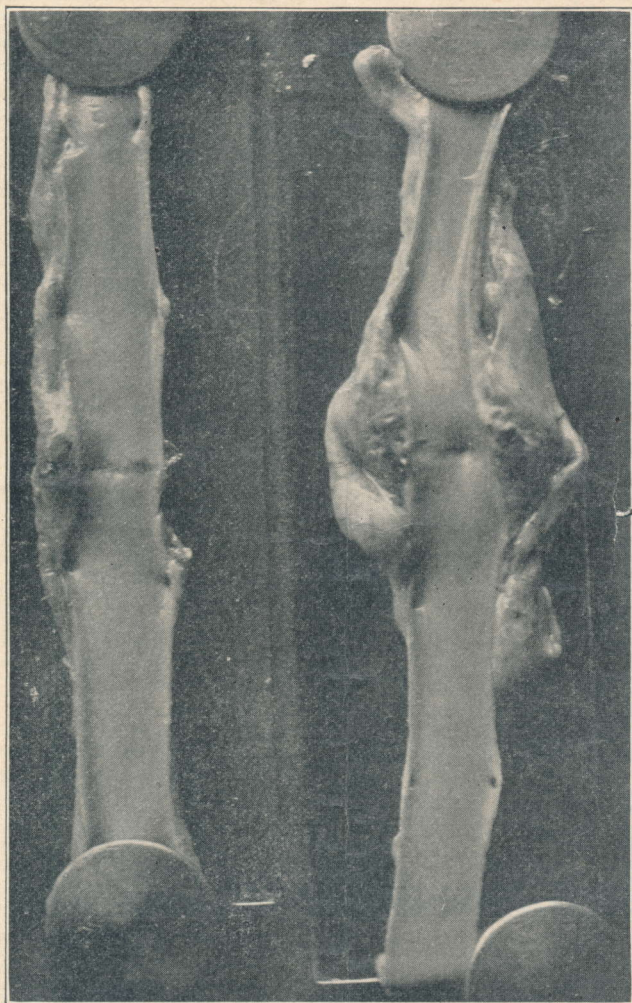


Fig. 9.—Result of common carotid operation. Dog died 36 days after operation; cause unknown. One vessel shows large gas tumor; neither showed any clot or thrombosis.

are now passed in their appropriate places. The first two needles are indicated by being grasped in marked mosquito forceps. The opposite cut end of the vessel is now grasped

by two fine tenaculums at points directly opposite each other. The two marked sutures are now passed through the vessel, midway between the tenaculums and on their appropriate sides; then they are passed through their appropriate holes in the second ring; the remaining sutures are then passed in their proper places through the vessel and through their

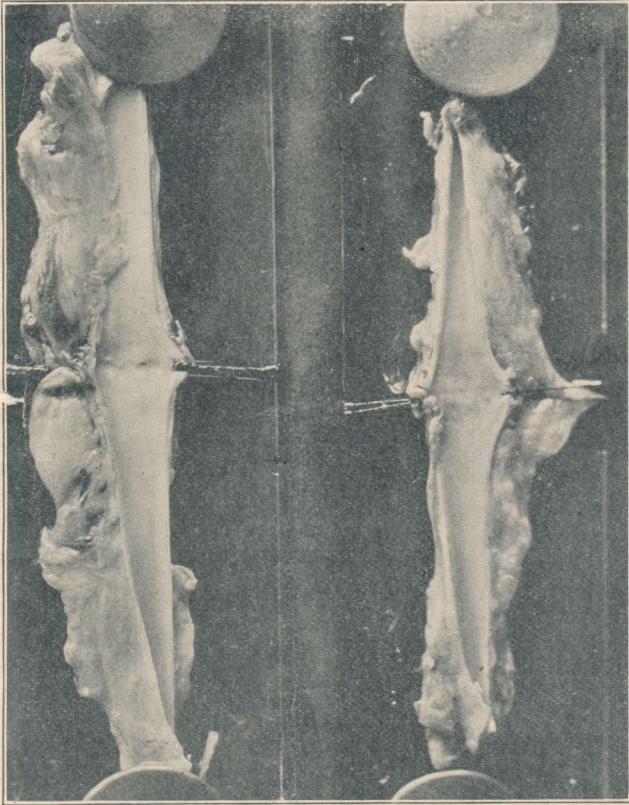


Fig. 10.—Common carotid operation. Dog killed 112 days later. The arteries were dissected out and demonstrated to be pulsating. They were clamped and cut distal to the anastomosis. In each instance the blood spurted. The vessels were then split open and mounted. Age of operation 112 days; magnesium practically gone; few small pieces still present; vessel smooth; no constriction.

proper holes in the second ring. The tenaculums are removed and the sutures drawn up and tied.

For large vessels, namely, above 5 mm. in diameter, the fourth method is preferred; for smaller vessels, the best

method is the second here mentioned, passing the sutures uniting the rings as a mattress stitch. All sutures are heavily smeared with petroleum. These sutures need not be boiled in petroleum. The petroleum is put on first to strengthen the thread and second to make it slip easily through the tissues and not drag connective tissue with the thread into the lumen of the vessel. And the petroleum is not intended, as in the suture method, to prevent thrombosis.

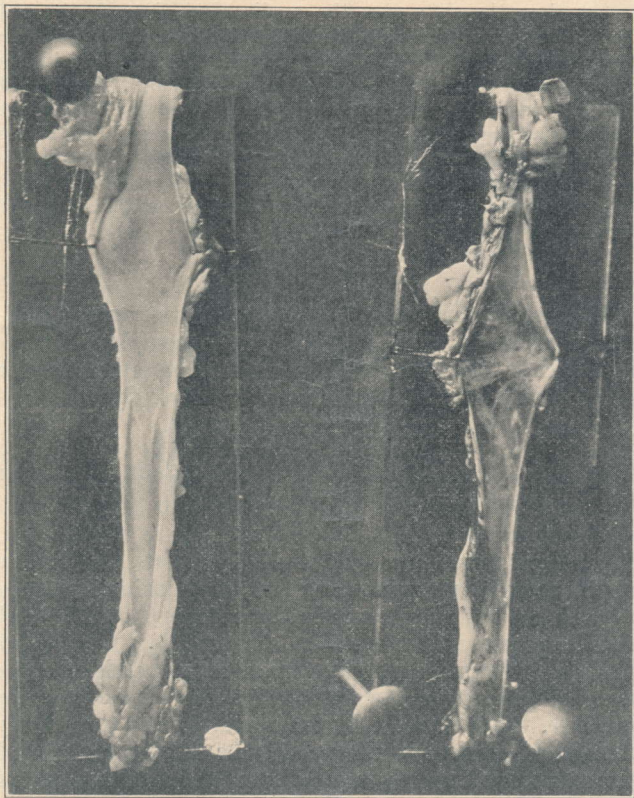


Fig. 11.—End-to-end anastomosis of external jugular vein. Operation 84 days old. Vessels smooth on the outside; blood flowing through them; magnesium rings absorbed except two small pieces in the tissue; no gas present. On opening the vessel; intima smooth and site of anastomosis determined with difficulty; 4 mm. rings used.

After the sutures are pulled up and tied, the clamps are removed, removing the distal one first. The fascia of the sheath is then sewed over the line of union, and the operation is completed.

## THE METHOD FOR REPAIR OF A LONGITUDINAL SLIT IN A BLOOD-VESSEL

In this operation the ring is replaced by a thin plate of metallic magnesium 1.5 mm. wide with holes 3 mm. apart (Fig. 6).

*Technic:* Clamp the vessel above and below the slit. Then locate the ends of the slit. Pass a guy ligature through the vessel walls at each end of the slit; select two plates a trifle longer than the slit; pass the needle, first through the end hole in one plate, then through both walls of the vessel a trifle beyond the end of the slit; next through the first hole in the opposite plate, then back through the second hole of the second plate, through the vessel walls on both sides of the slit; about 1 mm. from the edge, and finally through the second hole of the first plate. Taking another suture it is passed through the third and fourth holes of the plates in exactly the same way, and so on, the number of sutures depending on the length of the slit (Fig. 7).

### ABSORBABILITY

The period within which the magnesium rings are absorbed varies from 80 to 100 days for complete absorption. They maintain their original shape and hold for about thirty days and then begin to break down.

### TYING THE SUTURES

It has been determined that a ligature passed around a large artery and tied under five pounds pressure will shut off the blood stream but not injure the intima. A ligature passed in the same way but tied under eight pounds' pressure will cut the intima. Hence to bind the two rings together the sutures should be tied with a pressure of more than five and less than eight pounds. Throughout the operation the ends of the vessel should be washed in saline solution every few minutes. Occasionally, if the vessel is not thoroughly cleaned of connective tissue and the sutures are passed from without inward, a small tag of connective tissue may catch in the suture and be dragged through the vessel wall and project into the lumen. One point that must be carefully watched in regard to the sutures which hold the rings together is their cleanliness. These sutures must not be permitted to come in contact with blood or serum. This can be avoided by the use of gauze sponges or a piece of dentist's rubber dam appropriately placed. If the sutures are not kept clean

the material adherent to them is stripped off by the blood-vessel walls as the sutures are drawn up and collects as little masses around the sutures and form the starting points for thrombi.

#### THROMBOSIS

In this method there is nothing inside of the lumen of the vessels after the operation is completed; hence if trauma to the intima is avoided during the operation and the vessel is washed free from all clots and not tied tightly enough so that the rings will cut the intima where it bends outward to form the flange, thrombosis will not occur. Secondary thrombosis, such as occurs in the Payr operation from pressure necrosis, is impossible.

#### STRICTURE

In this method primary stricture cannot occur if the vessel is accurately measured and an appropriate-sized ring is at hand with which to make the anastomosis. Secondary stricture has never occurred in any of my experimental operations. In one specimen there was a small pouch at the site of operation.

#### HEMORRHAGE

Primary hemorrhage should not occur. In most of the anastomoses, there is absolutely no hemorrhage, not even a drop; secondary hemorrhage has occurred only in the presence of infection.

#### EMBOLUS

There is danger of this occurring only when thrombosis is present; hence to avoid embolus, avoid thrombosis. Its seriousness depends entirely on the point of lodgment of the embolus.

#### SUMMARY

The following principles must be kept in mind when making blood-vessel anastomoses with magnesium rings:

1. The vessel must be accurately and cleanly dissected.
2. All wound hemorrhage and oozing must be checked.
3. All clot must be removed from the ends of the blood-vessel.
4. A proper-sized ring must be used.

5. The rings must not be tied together under more than 8-lb. pressure or less than 5 lbs.
6. Traumatism to the intima behind the line of union must be avoided absolutely.
7. Gentleness and accuracy in all manipulations is absolutely essential.
8. Perfect asepsis must be maintained.

#### CONCLUSIONS

The use of magnesium rings to anastomose blood-vessels makes the operation safe, certain and easy, bringing it well within the skill of the average surgeon.

At the present time this operation is applicable, and should be done, in all wounds of the large vessels, both venous and arterial, and in all false aneurisms; and in all arterio-venous aneurisms. Under these conditions the short piece of vessel containing the opening can be removed bringing the ends together and making an end-to-end anastomosis, thus reestablishing the circulation through the vessel.

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